9.1 A Two-Scale Approximation for Nonlinear Energy Transfers in Wave Spectra

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1. INTRODUCTION

In most modern operational wave models such as WAM, nonlinear quadruplet wave-wave interactions (S_{nl}) are simulated by the Discrete Interaction Approximation (DIA) as parameterized by WAMD1 (1988). In Resio and Perrie (2008) we presented a new formulation for these wave-wave interactions, which we denoted as the Two-Scale Approximation (TSA). This method is based on the separation of a spectrum into a broad-scale component and a local-scale (or perturbation) component. TSA uses a parameterization of the broad-scale spectral structure, and preserves the degrees of freedom needed for a detailed-balance source term formulation, by including the second order scale in the approximation.

Previous tests have used idealized wave spectra, included JONSWAP spectra (Hasselmann et al., 1973) with selected peakednesses, finite depth tests, and perturbation cases (Resio and Perrie, 2008). These idealized cases showed that the TSA compares much more closely to the full Boltzmann integral (FBI) than DIA. Here, we show comparisons between TSA, FBI and DIA for measured field data collected at the US Army Field Research Facility (FRF) at Duck North Carolina during hurricane Wilma 2005. In the presentation we show comparisons among the 3 S_{nl} formulations using observed wave spectra from Currituck Sound.

Field data were collected in open ocean conditions from a directional waverider located off the US Army Field Research Facility at Duck, NC during hurricane Wilma. The waverider data consist of individual directional wave spectral cases, as the storm moved northeastward from Florida to beyond Cape Hatteras. Maximum wave heights reached 4.2 m.

Section 2 presents an overview description of the observed wave data from hurricane Wilma. Section 3 compares results from the three S_{nl} formulations using wave spectra from hurricane Wilma and Section 4 gives conclusions.

2. FIELD DATA FROM HURRICANE WILMA

Hurricane Wilma passed over Florida and propagated towards the northeast, passing east of Cape Hatteras over Florida and continuing to towards the northeast. By the time it passed by Cape Hatteras, maximum winds at directional waverider (#630) near the FRF near Duck NC were 14.6 ms^{-1} and maximum significant waves were 4.13 m at 22 EST (Eastern Standard Time) on 24 October 2005.

We focus on the waves at the peak of the storm during the period from 07 EST on 24 October to 07 EST on 25 October, as wind-generated waves reached peak values and then decayed as the storm moved past.

3. S_{nl} COMPARISONS

Figure 1 gives results from hurricane Wilma showing that TSA gives good overall simulation of FBI behavior on the spectral forward face, rear face and the equilibrium range. Details are given by Perrie and Resio (2008). TSA results are much better than DIA results, relative to FBI, in all spectral regions. Normalized root mean square errors (NRMSE) are given in Figure 2 for all spectra from hurricane Wilma during the period from 07 EST on October until 07 EST on 25 October, comparing TSA and DIA to FBI. For TSA, values for NRMSE are about half those of DIA. These NRMSE results show no apparent time variation.

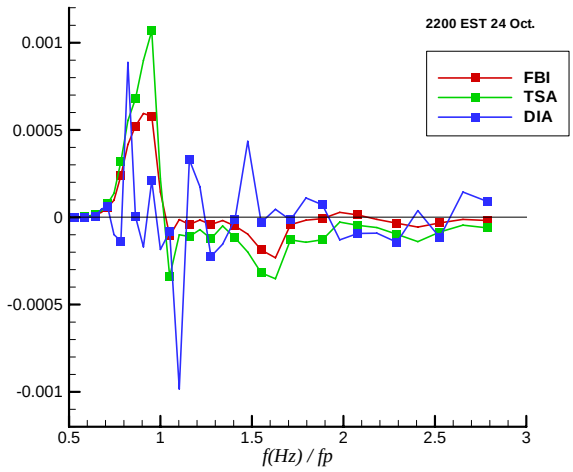

Figure 1. Normalized 1-d transfer with TSA and FBI compared with DIA, for the wave spectra observed by the directional waverider off Duck NC during hurricane Wilma (time and date indicated in panel), for developing wind-sea spectra.

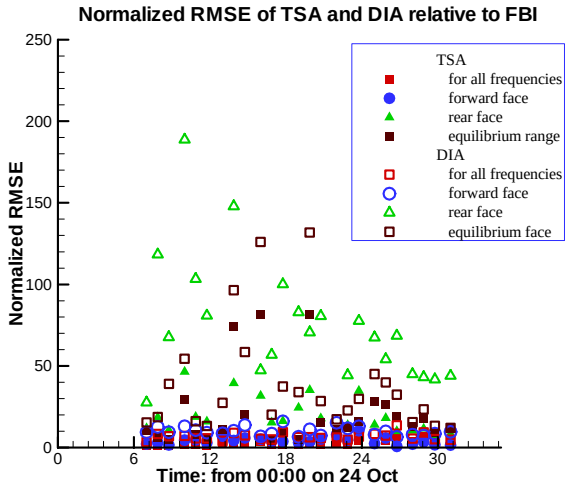

Figure 3. Error calculations for hurricane Wilma spectra cases showing normalized RMSE.

4. CONCLUSIONS

We have presented comparisons between the three formulations: TSA, DIA and FBI, using directional waverider data collected from open ocean conditions off the US Army Field Research Facility at Duck, North Carolina during hurricane Wilma.

TSA is expected to work well when the parametric terms capture much of the broad-scale behavior of the spectra. However, we can show that even in more complicated cases involving swell-windsea interactions, and shearing spectra, where observed spectra deviate from simple parametric forms, the TSA does a relatively good job of achieving a good comparison with FBI results. This conclusion applies to 1-d and 2-d results, particularly in the region of the low-frequency side of the spectral peak (not shown). Overall, DIA exhibits less prominence in regions of positive S_{nl} transfer rates, compared to TSA or FBI. Qualitative DIA differences are significantly dissimilar.

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